TIMING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a timing device such as a timing disk or a timing ruler which consists of a carrier having a first group of code markings disposed in at least one code track, which group of code markings is scanned by at least one sensor unit for producing a digital signal.

2. Description of the Related Art

A timing disk or a timing ruler of the aforedescribed type is described, for example, in U.S. patent 5,508,088 (common assignee's PWB basic patent). According to an embodiment of the device described therein, three concentric code tracks are arranged on a timing disk, with each of the code tracks having different markings. Three sensor units are required for scanning the three tracks, with the sensor units arranged in a similar manner as those of Figs. 1a, 1b or 2a, 2b of the known device. Accordingly, to scan several tracks disposed on a timing disk, several sensor units are arranged side-by-side in the radial direction, which increases the overall size of the scanning unit. In addition, several sensing devices require more complex electrical circuits, so that the device can more easily malfunction due to mechanical shock. The increased parts count and the more complex software introduces additional sources for errors. This is a significant disadvantage for the further improvement of printers, scanners and copiers. In practice, the carrier also ages which tend to make the carrier material opaque, or becomes contaminated, which is a particular problem with open systems such as inkjet printers. Both these situations can introduce errors if the sensor interprets the impurities as code markings.

SUMMARY OF THE INVENTION

It is an object of the present invention to improve the design of the timing device such as timing disks or timing rulers to make them more robust and less error-prone. It is another object to simultaneously capture several separate optical signals using one sensor unit through simple, material-specific and circuit-related measures. It is yet another object to provide continuous signal amplification, as used for example with potentiometer systems, and to economically produce a simple position measurement device, for example for a steering angle sensor.

These and other objects are solved with the invention by the characterizing features recited in the claims. It has been observed that two or more groups of code markings can be detected independently from one another using a single sensor unit, if the code markings of the groups have a different optical density. "Optical density" refers to a gradation in gray levels between approximately 100% (dark-gray) to approximately 0% (fully transparent, fully reflective). Absolute positioning preferably is not attained by using bars, but rather by taking advantage of the increasing or decreasing gray levels. The optical density changes in this case, so that the sensor produces signals having a high intensity and corresponding to a low optical density and produces signals having a low intensity and corresponding to a high optical density, or vice versa.

The different groups of code markings in a track can be scanned simultaneously using a two-channel or a multi--channel sensor unit. The groups of code markings may also overlap one another. It is sufficient if the sensor unit senses a noticeable change in the optical density, which causes a corresponding change in the voltage captured by the sensor unit. Voltage

differences of, for example, 100 μV have proven to be adequate; however, other voltage differences can be used depending to the sensitivity of the measurement devices.

Suitable sensor units consist of an LED or another light source and of photo transistors or other light sensitive scanning devices. For controlling start and/or end positions or for calibration purposes, these sensor units can detect signals with either a constant separation or an arbitrary separation over the entire segment ranges of the timing disk or the timing ruler.

Other objects and features of the present invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are intended solely for purposes of illustration and not as a definition of the limits of the invention, for which reference should be made to the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, wherein like reference numerals delineate similar elements throughout the several views:

FIG. 1a and b show a segment of a timing disk with different groups of code markings;

FIG. 2 shows a scanning signal from a sensor unit during scanning of a first group of code markings;

FIG. 3 shows a scanning signal from a sensor unit during scanning of a second group of code markings; and

FIG. 4 shows a combination of the scanning signals of Fig. 2 and Fig. 3.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

Fig. 1a and b depict the segment of a timing disk having dark-gray and light-gray code bars. The steps in the different gray levels have to be selected so that aging and/or contamination of the timing disk does not produce erroneous scanning signals. The scanning signals of the regions a-b, b-c from the segment of the timing disk illustrated and Fig. 1b are recorded in the voltage-frequency curves depicted in Figs. 2 and 3. As can be seen, a large signal voltage corresponding to a large amplitude (due to the black tint of the bars) is produced in the region a-b, whereas only a reduced signal voltage corresponding to a smaller amplitude (due to the lesser optical density of the code bars) is detected in the region b-c. Comparable arguments can be applied to reflecting timing disks.

The following description is intended to explain the principle of the positioning measurement in more detail with reference to a specific example. Positioning measurement devices should enable contact-less photoelectric scanning of an incremental scale, while maintaining a high measurement accuracy. The pitch of the code markings can be changed with proper circuit design, for example by using phase-multiplying circuits or potentiometer circuits. If the pitch consists of consecutive light and a dark fields of identical size, then a photo transistor scanning across the pitch will produce a sinusoidal voltage with a wavelength corresponding to the sum of the two lengths of a light field and a dark field. Alternatively, the existing pitch can be subdivided further, thereby producing a potentiometer circuit.

The signal intensity of the standard timing disk remains constant. With an analog sensor, for example a sensor of the type Hewlett-Packard (Agilent Technologies) - Q 9846+0007, additional pulses for calibration are produced without requiring additional code tracks. An analog signal derived therefrom can be used for advancing paper, for stitching lines and/or for absolute positioning in printers, scanners or copiers.

According to the invention, in addition to the existing signals from the first group of code markings, a second variable is introduced, for example a change of the gray level of the code markings. The gray level determines the light transparency or the optical density and thereby the amplitude of signal. It is also possible to identify each angular position as an absolute position and to identify intermediate steps in analogy to an optical potentiometer.

Arbitrary intermediate steps can be encoded by a suitable gradation of the gray levels. In this way, certain segments of a timing disk or a timing ruler can be defined that are associated with additional functions.

Advantageously, although not necessarily, the signals of the first group of code markings can have a constant period independent of the gray level. Control devices of this type, due to their different light transparency, can also be applied to timing disks or timing rulers having slit markers for photo interrupters or other devices that produce an analog signal.

Thus, while there have been shown and described and pointed out fundamental novel features of the invention as applied to a preferred embodiment thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices illustrated, and in their operation, may be made by those skilled in the art without departing from the spirit of the invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. Substitutions of elements from one described embodiment to another are also fully intended and contemplated. It is also to be understood that the drawings are not necessarily drawn to scale but that they are merely conceptual in nature. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.